PERFORMANCE SPECIFICATION
FOR THE

BATTERY MONITORING SYSTEM
OF THE

PROGRAM EXECUTIVE OFFICE GROUND COMBAT SYSTEMS (PEO GCS)

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1. SCOPE

1.1 Scope. This specification covers the performance, test, manufacture and acceptance requirements for the Battery Monitoring System (BMS).

1.2 Item Overview. The Battery Monitoring System (BMS) is designed to be installed on a pair of 12V lead acid vehicle batteries which are connected in series to give a 24V vehicle supply. Lead acid batteries include, but are not limited to, 6TL, 6TAGM, and AGM Group 31 batteries.

The BMS shall provide battery measurement and monitoring. The BMS has two modes of operation, 'ACTIVE' and 'STANDBY'. The 'ACTIVE' state is used when the vehicle is in use and the Master Power switch is in the ON position. The 'STANDBY' mode is when the vehicle is not in use and the Master Power switch is in the OFF position.

The following parameters are measured for each battery approximately every 15 seconds while in the 'ACTIVE' mode and are available via the J1939 data bus.

- State of Health (%)
- State of Charge (%)
- Voltage (V)
- Current (A)
- Time Remaining (at current rate of discharge)
- Temperature (C)

Further information regarding the data available on the data bus and its formatting can be found in SAE J1939 standard.

The BMS shall be able to track battery parameters while in the 'STANDBY' mode to ensure proper battery information.

NOTES:

The battery that provides the 0V connection with the vehicle is designated the 'LOWER' battery in this document.

The battery that provides the 24V connection with the vehicle is designated the "UPPER" battery in this document.

One 'LOWER' and one 'UPPER' battery in series is considered one battery pair.

All definitions in this specification are in reference to one battery pair, unless specifically noted otherwise.

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2. APPLICABLE DOCUMENTS

2.1 Government Documents.

2.1.1 Specifications, Standards and Handbooks. The following specifications, standards and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

FEDERAL SPECIFICATIONS

A-A-59133	Cleaning compound, High Pressure (Steam) Cleaner
A-A-52557	Fuel Oil, Diesel; For Posts, Camps and Stations
P-C-437B	Cleaning Compound, High Pressure (Steam) Cleaner
P-D-220D	Detergent, General Purpose

FEDERAL STANDARDS

FED-STD-595	Colors Used in Government Procurement

MILITARY DETAIL SPECIFICATIONS

MIL-DTL-5624T	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-DTL-83133F	Turbine Fuel, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37)

MILITARY SPECIFICATIONS

MIL-W-5088L	Wiring, Aerospace Vehicle

MILITARY STANDARDS

MIL-STD-461F	Requirements for the Control of Electromagnetic Interference, Emission and Susceptibility
MIL-STD-810F	Environmental Test Methods and Engineering Guidelines

MIL-STD-1472F	Design Criteria Standard for Human Engineering
MIL-STD-1275D	Characteristics of 28 volt DC Electrical Systems in Military Vehicles
MIL-STD-1686C	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-STD-464A	Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-171	Finishing of Metal and Wood Surfaces

MILITARY PREFERENCES

MIL-PRF-16884L	Fuel, Naval Distillate
MIL-PRF-46170D	Hydraulic Fluid, Rust Inhibited, Fire Resistant, Synthetic Hydrocarbon Base, NATO Code No. H-544
MIL-PRF-6083F	Hydraulic Fluid, Petroleum Base, For Preservation and Operation

HANDBOOKS

MIL-HDBK-454	General Guideline for Electronic Equipment

Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

2.1.2 Other Government Documents, Drawings, and Publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

19207-12462906	ESS Requirements for Engineering Development and Manufacturing Implementation
19207-12350824	Exterior Paint System

Copies of specifications, standards, handbooks, drawings and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.

2.2 Non-Government Publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents that are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

ANSI J-STD-001	American National Standard Electronic Industries Association Joint Industry Standard Requirements for Soldered Electrical and Electronic Assemblies
ASTM D1655-87	Standard Specification for Aviation Turbine Fuels
ASTM D4814	Standard Specification for Automotive Spark-Ignition Engine Fuel
ASTM D975-81	Standard Specification for Diesel Fuel Oils
GEIA-STD-0005-1	Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder
GEIA-STD-0005-2	Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems
GEIA-STD-0006	Requirements for Using Solder Dip to Replace the Finish on Electronic Piece Parts
IPC-A-610 Class 3	Institute for Interconnecting and Packaging Electronic Circuits Acceptability of Electronic Assemblies
IPC D-275	Institute for Interconnecting and Packaging Electronic Circuits Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies
ISO 10012-1	The International Organization for Quality Assurance Requirements for Standardization, Measuring Equipment
SAE J1939	Recommended Practice for a Serial Control and Communications Vehicle Network

SAE J2284-2	High Speed CAN (HSC) for Vehicle Applications at 250 Kbps
ISO 11898	International Organization for Standardization, Road vehicles -- Controller area network (CAN)
OSHA 29 CFR 1910	Occupational Safety and Health Standards

Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents may also be available in or through libraries or other informational services.

2.3 Order of Precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets or military standards) the text of this document takes precedence. Nothing in this document however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First Article. When specified (see 6.3), the BMS shall be subjected to first article inspection (see 4.4) to demonstrate the adequacy and suitability of the supplier's processes and procedures in achieving the specified performance.

3.2 Materials. Materials shall be in accordance with the drawings, parts lists and other documents specified on BMS Drawings. All materials selected shall be uniform in quality and free from defects that would be considered unacceptable in the consumer market for a comparable commercial product. See section 3.7.7 for excluded materials.

3.3 Design and Construction. Design and construction of the BMS including the factors listed below shall be in guidelines of the standards, specifications, pamphlets, regulations and other documents specified herein.

a. Dimensions and tolerances
b. Protective finish
c. Connector requirements
d. Product marking.

3.3.1 Weight. The weight of the BMS, excluding external cables, shall not exceed 5 pounds per battery pair.

3.3.2 Manufacturing Processes.

3.3.2.1 Printed Wiring. Printed wiring shall be designed and constructed in accordance with IPC D-275.

3.3.2.2 Wire Marking. Wire marking shall be in accordance with MIL-W-5088L.

3.3.2.3 Soldering. Soldering of electrical and electronic components shall be in accordance with ANSI J-STD-001 or approved equivalent.

3.3.2.4 Environmental Stress Screening (ESS). Unless otherwise specified, the BMS shall be subjected to ESS in accordance with 19207-12462906.

3.3.2.5 Electrostatic Discharge (ESD). The BMS shall be immune to damage or upset due to personnel-borne ESD and comply with MIL-STD-1686C, IPC-A-610, and MIL-STD-464A.

3.3.3 Bonds and Grounds.

3.3.3.1 Electrical Connector Receptacles. For enclosure mounted electrical connector receptacles, DC bonding resistance measured with the interfacing electrical cable disconnected, shall not exceed 5 milliohms.

3.3.3.2 Grounding. The BMS shall provide a lug for grounding provisions at the control unit level. This shall accommodate a non-painted 0.38” 8-32 screw.

3.3.4 Dielectric Withstanding Voltage and Insulation Resistance. Electrical connections terminating at external connectors and not internally connected to semiconductors shall be capable of withstanding 500 VDC between unrelated circuits and to the case. The insulation resistance between all unrelated circuits and the resistance between the circuitry and the case shall be greater than 10 Megaohms (MΩ) for up to 5 seconds.

3.3.5 Electrical Safety. Electrical portions of the BMS shall comply with the safety requirements of MIL-HDBK-454, Guidelines 1, 3, and 8.

3.3.5.1 Cables, Leads and Spare Pins. Unused electrical cables and leads shall be provided with dummy receptacles or covers. Unused connector slots shall be filled with dummy pins or capped.

3.3.5.2 Touch Surface Temperature. All BMS components shall include a “Caution: Hot Surface” label as operating temperatures are above safe touch temperatures as spelled out in MIL-STD-1472F.

3.3.6 Workmanship. BMS shall be free of cracks, dents, scratches, burrs, sharp edges, loose parts, foreign matter, or any other evidence of poor workmanship that would render the unit unsuitable for its intended use. Acceptance criteria for all quality characteristics of a visual or tactile nature that are not specifically addressed in this specification or in referenced documents shall be in accordance with ANSI/J-STD-001 and ANSI/IPC-A-610 Class 3 for CCA.

3.4 Performance Requirements.

3.4.1 Control Unit. The BMS control unit must control all sensors for vehicle batteries. Each connector between each module must be keyed.

3.4.2 Sensor. The sensor is a small unit that attaches directly to the negative battery post of the ‘LOWER’ battery. The sensor is interfaced directly to the BMS control unit which uses the sensor to measure parameters of the battery pair.

The outer dimensions of the sensor must comply with a standard battery terminal post allowing connection of the standard vehicle harness. Unique sensors may be utilized on a case-by-case basis. Space claims will be provided, however the sensor shall not add a height of more than ½” to the top of the existing battery terminal post.

3.4.3 Sensor Harness. The Sensor Harness provides the necessary connections between the batteries, the Sensor Unit and the Control Unit. This harness shall be able to have a maximum length of 26 feet without signal degradation.

3.4.4 Interfaces

3.4.4.1 Sensor Connector. This connector interfaces with the Sensor harness and is considered an internal interface of the BMS.

3.4.4.2 Battery Master Input. The BMS shall have an isolated Battery Master Input that shall be connected to the vehicle supply via the vehicle Master Power Switch. This signal shall be used to select the operating mode of the Control Unit and determine the timing of CAN message transmissions. All control unit(s) and sensors shall have the correct timing relationship over the CAN Bus.

A DC voltage of 15-30V applied to this interface shall put the Control Unit in 'ACTIVE' Mode. Removing the voltage signal to the interface shall put the unit in 'STANDBY' Mode.

3.4.4.3 CAN Bus Interface. The BMS shall transmit and receive messages over the CAN bus. The CAN Bus connector provides the main vehicle interface with the BMS. The physical communication data bus is described in SAE J2284-2.

The BMS shall be externally programmable through the vehicle interface or the BMS CANbus.

The BMS shall not be required to be the terminating device or have a termination resistance on the CAN bus. If the BMS has a termination resistance, it must be capable of removing the resistance from the string.

The BMS shall meet the requirements of SAE J1939. Additional information is available in ISO11898.

The BMS shall be able to download the battery type information through the CAN Bus.
BMS output parameters in table 1 (see section 3.4.5) shall be sent to the vehicle via the CAN Bus.

3.4.5 Performance Characteristics

The performance characteristics of the BMS are listed per battery in the table below.

- State of Charge (%) is the amount of charge available compared the present capacity of the battery to hold charge.
- State of Health (%) is determined by the amount of charge the battery is able to hold (reserve state of health) and the ability of the battery to deliver the charge (cranking state of health) compared to the normal specified new battery capacity.
- Voltage is the DC voltage measured across each battery.
- Current is the average current read in at least the last 500ms through the battery string. This must have the average of at least 5 recorded points.
- Temperature (˚F) is the temperature measured a battery terminal.
- Time remaining is the amount of time the battery has at the present state of discharge before it is completely discharged.

Table I. Performance Characteristics

Data	Range	Resolution	Error	Notes
State of Charge (%)	0% to 100%	1%	± 5%	100% = fully charged. 0% = empty
State of Health (%)	0% to 100%	1%	± 5%	100% = fully healthy 0% = unhealthy
Voltage (V)	0V to 16.6V	0.1 Volt	± 5%	
Current (A)	-999A to +999A	1 Amp	± 5%	+ value = battery charging - value = battery discharging
Temperature (˚F)	-60˚F to +194˚F	1˚F	± 5%	
Time Remaining (in Hrs)	0 – 40 hours (limits at 40hrs)	1/10 hour	N/A	Decimal hours.

3.4.6 Power Requirements.

3.4.6.1 Input Voltages. The BMS shall operate from a nominal supply voltage of +28 volts DC. ACTIVE Mode requires a steady state lower limit of 15 volts and a steady state upper limit of 30 volts. The STANDBY mode requires a lower limit of 10 volts and an upper limit of 30 volts. After operation with supply voltage within the range specified above for 1 minute or more, the BMS shall be capable of maintaining operation for at least 1 minute with supply voltage as low as 16 VDC. The BMS shall tolerate ripple with peak amplitudes up to ±2.0 volts and frequency components within the 50 Hertz (Hz) to 200 kilohertz (kHz) range.

3.4.6.2 Power Line to Case Isolation. The supply voltages and associated returns shall be isolated from the BMS chassis by at least 1.0 MΩ DC resistance. All internal power supply returns shall be isolated from the equipment case by at least 1.0 MΩ DC resistance.

3.4.6.3 Input Power. The total power consumption of the BMS shall not exceed 10 watts under ‘ACTIVE’ conditions. The total power consumption of the BMS shall not exceed 1 watt while in ‘STANDBY Mode’.

3.4.6.4 Transient Conditions.

3.4.6.4.1 Surges. Surge transients exported and imported by the BMS shall be within the limits specified in the condition in Figure 1. The BMS shall not cause any excursion outside these limits nor cause damage to other equipment designed to tolerate transients within these limits nor be damaged by surge transients within these limits.

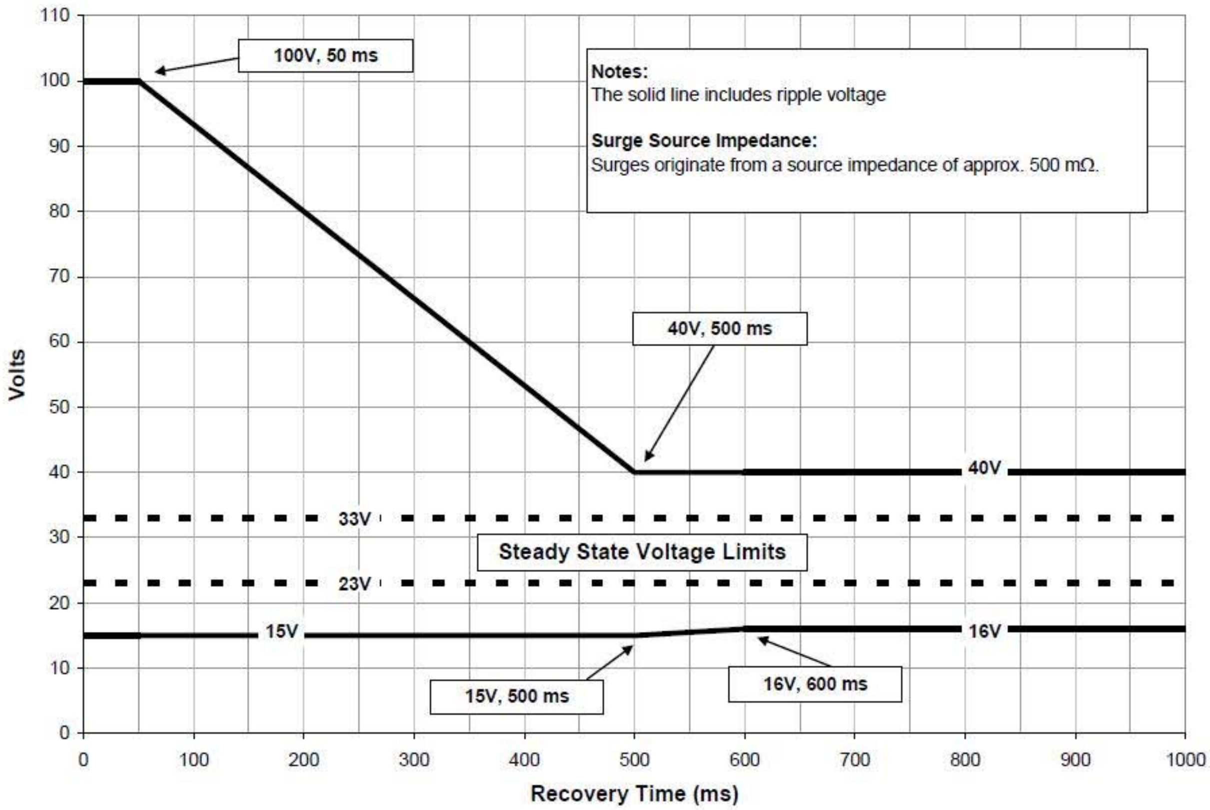

FIGURE 1. Envelope of Surges in Generator-only Mode for 28 VDC Systems.

3.4.6.4.2 Spikes. Spike transients exported and imported by the BMS shall be within the limits specified in the condition in Figure 2. The BMS shall not cause any excursion outside these limits nor cause damage to other equipment designed to tolerate transients within these limits nor be damaged by surge transients within these limits.

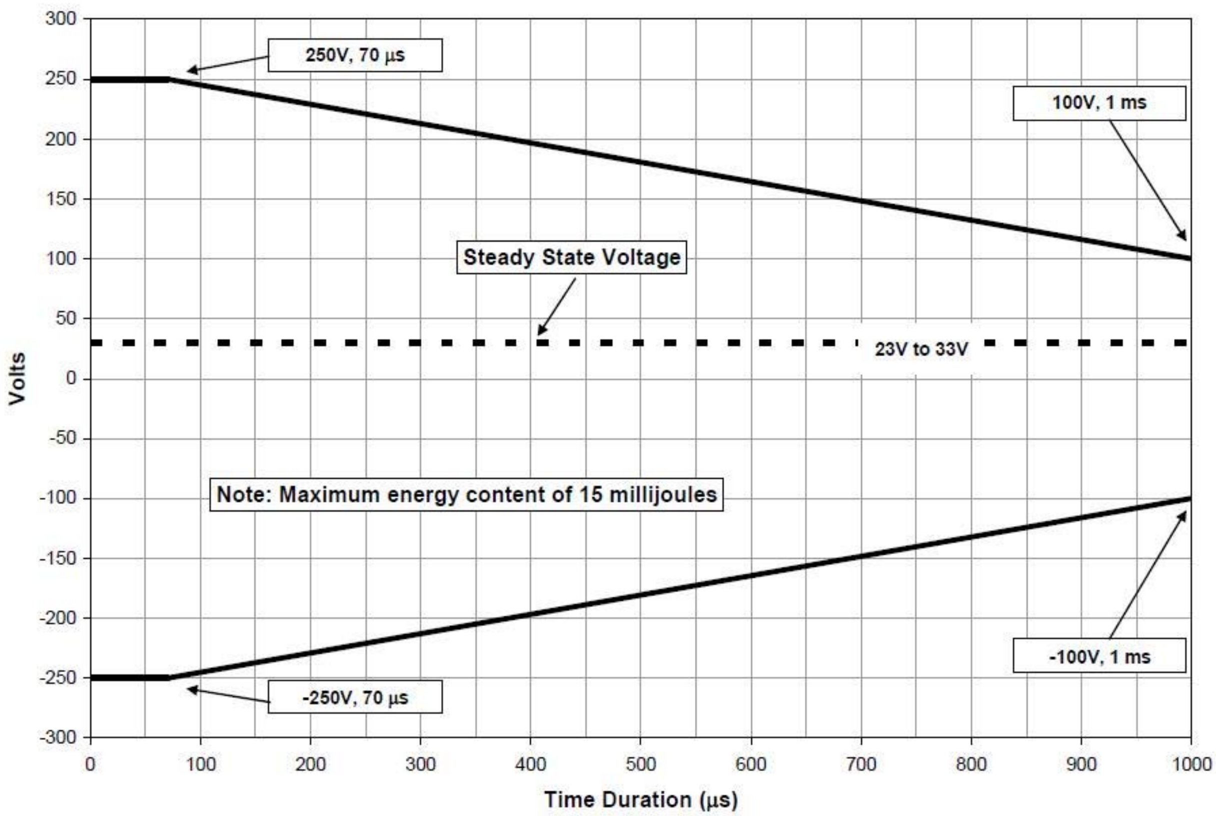

FIGURE 2. Envelope of Spikes in Generator-only Mode for 28 VDC Systems.

3.4.6.4.3 Starting. Starting transients exported and imported by the BMS shall be within the limits specified in the condition in Figure 3. The BMS shall not cause any excursion outside these limits nor cause damage to other equipment designed to tolerate transients within these limits.

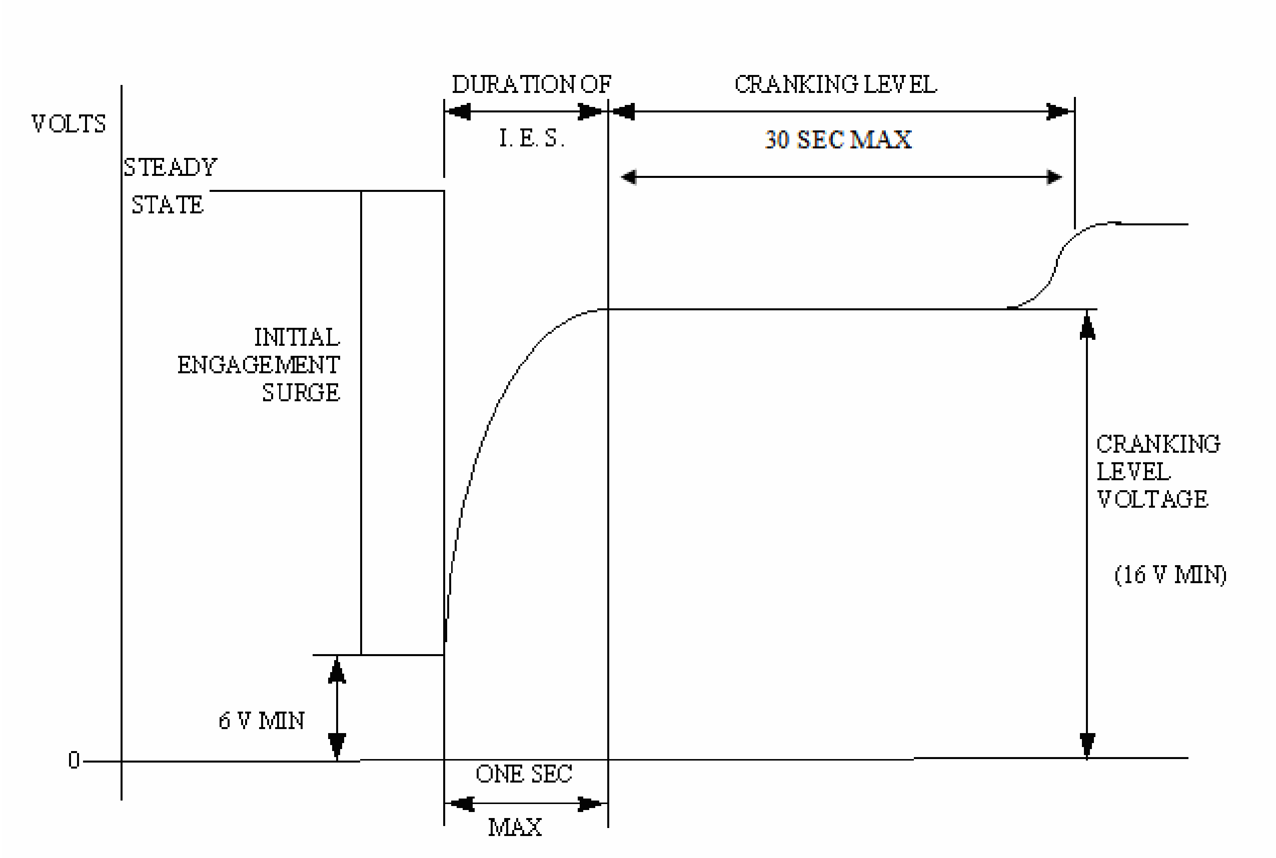

FIGURE 3. Starting and Cranking for 28 VDC Systems.

3.4.6.5 Steady State Conditions.

3.4.6.5.1 Surges. Surge transients exported and imported by the BMS shall be within the limits specified in the condition in Figure 4. The BMS shall not cause any excursion outside these limits nor cause damage to other equipment designed to tolerate transients within these limits nor be damaged by surge transients within these limits.

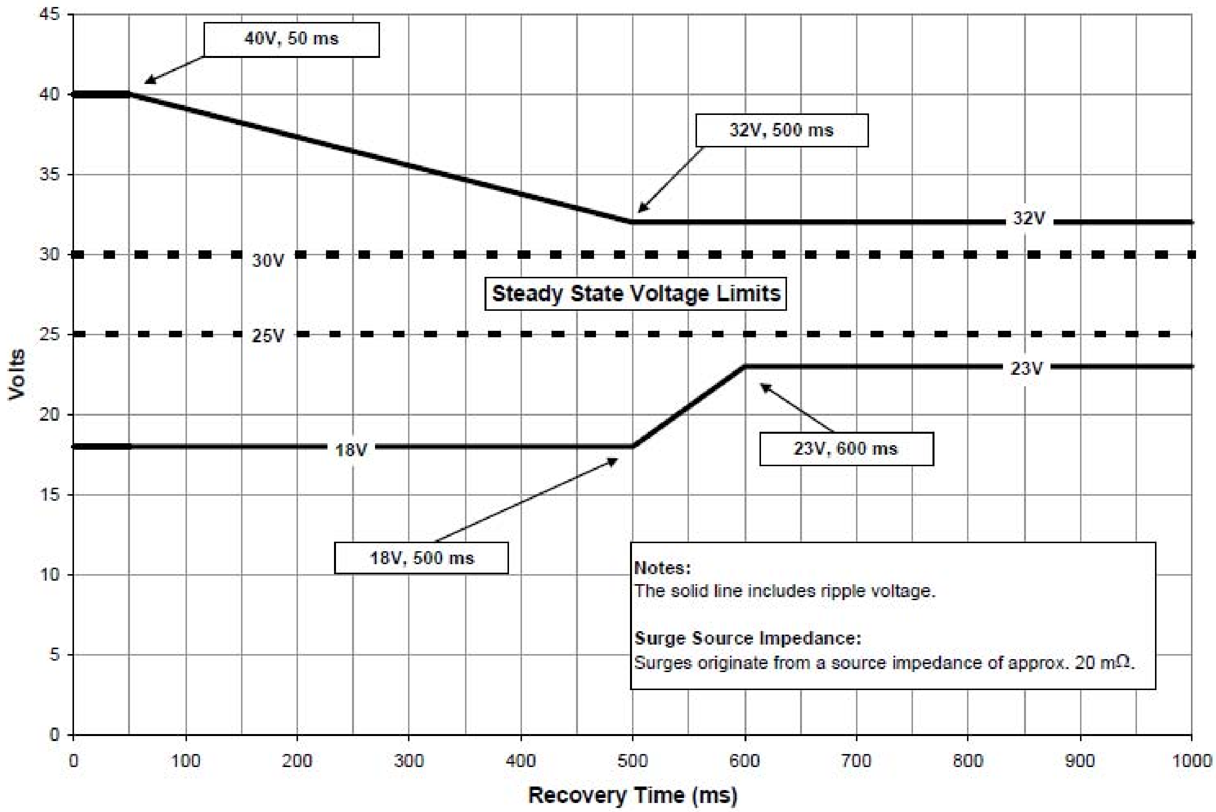

FIGURE 4. Surges in Steady State Mode for 28 VDC Systems

3.4.6.5.2 Spikes. Spike transients exported and imported by the BMS shall be within the limits specified in the condition in Figure 5. The BMS shall not cause any excursion outside these limits nor cause damage to other equipment designed to tolerate transients within these limits nor be damaged by surge transients within these limits.

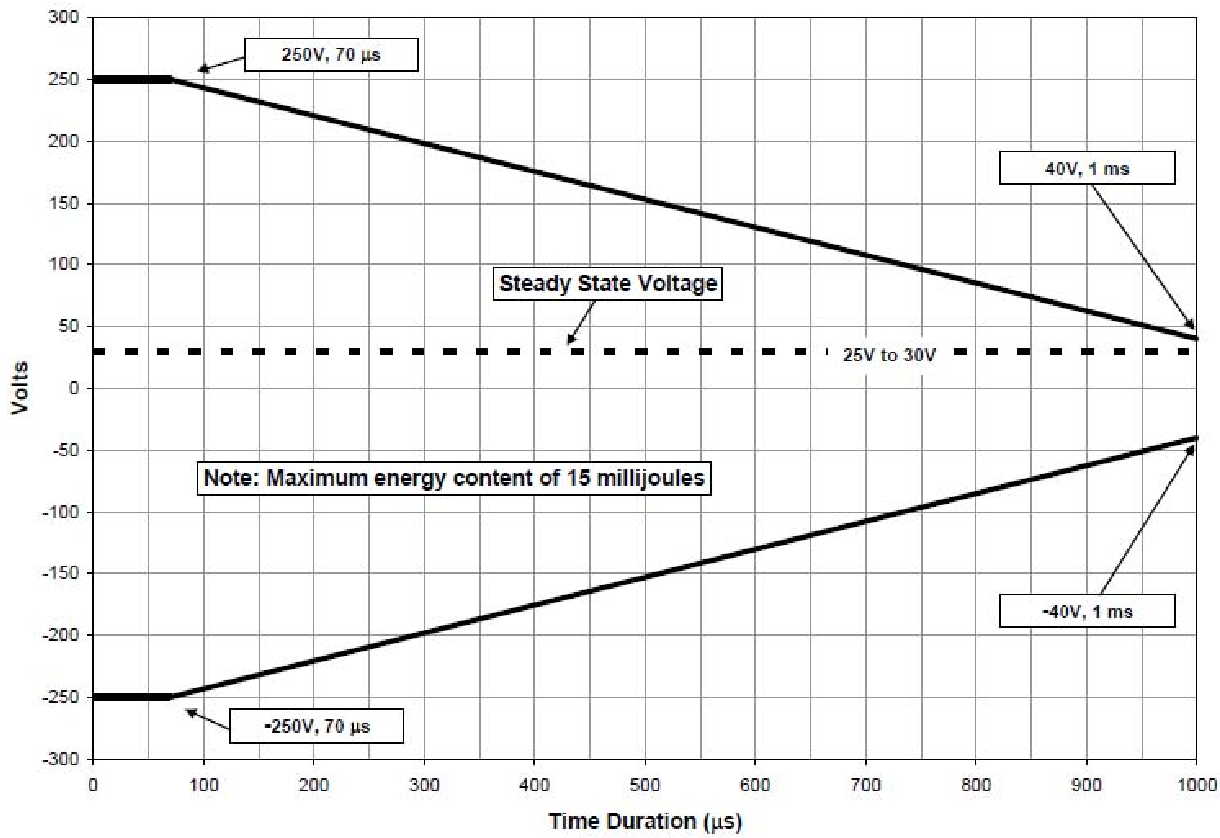

FIGURE 5. Spikes in Steady State Mode for 28 VDC Systems

3.4.7 Built-In Test. An internal Built-In Test (BIT) capability shall be provided to detect and isolate failures to the BMS LRU level through databus connection and/or status indicators. Start up BIT (SBIT) shall execute automatically at the BMS power up and Background BIT (BBIT) periodically run under firmware control while the BMS remains powered. BBIT shall not degrade the performance of the BMS. The time required to execute SBIT shall not exceed 15 seconds. BIT results shall be available to the operator and maintainer.

3.4.8 Reprogrammability. The non-volatile memory in the BMS shall be reprogrammable via CAN bus within 15 minutes without the need to cycle power. Once in reprogramming mode, the BMS shall remain in that mode until commanded on the CAN bus.

3.4.9 Pin Disconnects. The BMS shall include pin disconnects or equivalent circuits capable of carrying a TTL signal at all connections between LRUs.

3.5 Environmental Conditions.

3.5.1 Shock.

3.5.1.1 Functional Shock. The BMS shall demonstrate no performance or physical degradation during or after functional shock stresses of 15 g's for 75 ms, half-sine shock pulses.

3.5.1.2 Severe Shock. The BMS shall remain mounted and demonstrate no performance or physical degradation after-shock stresses of 30 g's for 18 ms, half-sine shock pulses.

3.5.1.3 Gun Firing Shock. The BMS shall meet the performance requirements during and after exposure to shock impulses of 200 $\pm$ 20 g's, 1.0 $\pm$ 0.1 milliseconds (ms) half sine wave applied in each direction of three mutually perpendicular axes.

3.5.1.4 Ballistic Shock. When mounted as in the vehicle, Battery Monitoring System shall meet the performance requirements after exposure to shock impulses of at least 1.5 times the magnitude of the equivalent static acceleration curve provided in Table II.

Table II. Ballistic Shock Equivalent Static Acceleration

Frequency (Hz)	(1.5) g's
30	20
175	500
10,000	30,000
100,000	300,000

3.5.1.5 Bench Handling Shock. The Battery Monitoring System shall meet the performance requirements after being lifted to pivot on each corner and dropped on each face adjacent to that corner. The corner opposite the pivot shall be raised so the lesser of the following is true:

- The corner opposite the pivot is no more than four inches off the table
- The face being dropped makes no more that 45º angle with respect to the table
- The lifted edge is just below the point of perfect balance

3.5.2 Vibration. The BMS shall demonstrate no performance or physical degradation during or after the vibration stresses outlined in Appendix B.

3.5.3 High Temperature.

3.5.3.1 Storage. The entire BMS shall demonstrate no performance or physical degradation after storage at temperatures up to 160°F (71°C) for extended duration.

3.5.3.2 Operation. The BMS sensors shall demonstrate no performance or physical degradation during or after continuous operation at a surrounding ambient of 194°F (90°C). The BMS control unit shall demonstrate no performance or physical degradation during or after continuous operation at 160°F (71°C).

3.5.4 Low Temperature.

3.5.4.1 Storage. The BMS shall demonstrate no performance or physical degradation after storage at a constant temperature of -60°F (-51°C).

3.5.4.2 Operation. The BMS shall demonstrate no performance or physical degradation during or after continuous operation at a surrounding ambient of -60°F (-51°C).

3.5.5 Leakage (Immersion). The BMS shall limit water entry and shall demonstrate no performance or physical degradation after 0.5 hours immersion in water to a depth of six feet.

3.5.6 Humidity. The BMS shall demonstrate no performance or physical degradation during or after exposure to aggravated high humidity conditions up to and including:

a. Temperature range: 86°F to 149°F (30° to 65C°).
b. Relative humidity range: 95 ± 5 percent.

3.5.7 Steam and Waterjet Cleaning. The BMS shall demonstrate no performance or physical degradation after being subjected to steam and waterjet cleaning with a cleaner conforming to P-C-437B, type II, P-D-220D, or commercial equivalent.

3.5.8 Salt Fog. The assembly shall meet the performance requirements during and after exposure to a salt fog atmosphere for 48 hours. The salt fog atmosphere shall be defined as:

- 5% by weight NaCl, and 95% by weight distilled water,
- Fog density shall be approximately 3 quarts solution per 10 ft^3 per 24 hours, and
- Ambient temperatures between 90 and 95°F.

3.5.9 Chemicals. The assembly shall meet the performance requirements during and after exposure to vapors of and in direct contact with the following materials for 48 hours:

a. Fuel per A-A-52557 (DF-1, DF-2, or DF-A) or ASTM D975-81 (Commercial diesel No. 1-D or No. 2-D)
b. ASTM D4814 (MoGas) or regular automotive leaded gasoline
c. MIL-DTL-5624T (grade JP-4 or JP-5), MIL-DTL-83133F (Grade JP-8) or ASTM D1655-87 (Commercial turbine jet-A or A-1)
d. Marine diesel fuel oil per MIL-PRF-16884L
e. Hydraulic fluid per MIL-PRF-46170D
f. Petroleum hydraulic fluid per MIL-PRF-6083F
g. Cleaning agents per A-A-59133

3.5.10 Sand. The Battery Monitoring System shall meet the performance requirements during and after exposure to sand particles of 0.01 to 1.00 mm diameter blown by air with a velocity of at least 3030 ft/min against external component surfaces for one hour. Sand concentrations shall be 0.3 ± 0.2 grams per cubic foot.

3.5.11 Dust. The Battery Monitoring System shall meet the performance requirements during and after exposure to dust laden air with dust particles of 0.0001 to 0.0100 mm diameter and 6 x 10^{-9} g/cm^3 blown against external component surfaces at an air velocity of 1750 ft/min for six hours.

3.5.12 Elevation - Operating. The Battery Monitoring System shall meet the performance requirements during and after exposure to elevations from 1312 feet below sea level to 15,000 feet above sea level while in operation.

3.5.13 Elevation - Nonoperating. The Battery Monitoring System shall meet the performance requirements within 40 minutes after recovering from exposure to elevations above 15,000 feet up to 50,000 feet above sea level.

3.5.14 Altitude Change. The Battery Monitoring System shall meet the performance requirements and not be damaged by rates of ascent and descent of up to 10 meters/second in a non-operating environment.

3.6 Electromagnetic Compatibility. The BMS shall comply with the requirements of MIL-STD-461F for CE101, CS101, CS114, CS115, CS116, RE102 and RS103 for Army Ground vehicle applications. The RS103 test shall be met to 40 GHz.

3.7 Product Characteristics.

3.7.1 Paint, Protective Finishes, and Coatings. Protective finishes shall be in accordance with MIL-STD-171E. Application of Chemical Agent Resistive Coating (CARC) paint shall be in accordance with 19207-12350824. The BMS shall be painted FED-STD-595B color 24533, Sea Foam Green, with a semi-gloss.

3.7.2 Corrosion Resistance. Metals and alloys used in the BMS that are exposed to corrosive environmental conditions shall be corrosion resistant or metallurgically processed to resist corrosion. Dissimilar metal combinations that promote corrosion through galvanic action shall be insulated to prevent corrosion.

3.7.3 Fungal Growth. Materials used in the BMS shall not support fungal growth.

3.7.4 Reliability. The BMS shall be designed to achieve a mean time between failure (MTBF) of at least 20,000 hours.

3.7.5 Maintainability. The BMS shall be designed to achieve a median time to repair (MedTTR) of no more than 3 hours over an operational life of 20,000 hours before failure.

3.7.6 Restricted Materials. The BMS shall be produced according to the restrictions listed in 3.7.6.1 and in Appendix C.

3.7.6.1 Lead Free Risk Management

3.7.6.1.1 General. The Subcontractor shall prepare and submit a Lead-Free Control Plan (LFCP) to the vehicle integrator for approval. GEIA-STD-0005-1, "Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder" or an equivalent shall be used as a basis for preparation of a LFCP. The plan shall address all solders and Pb-free finishes in delivered.

3.7.6.1.2 Solder. The Subcontractor shall continue using eutectic tin lead solders (Sn60 or Sn63) and tin-lead component finishes on all products provided to Contractor. Whenever tin-lead finishes are not available the supplier shall select finishes such that the reliability change is negligible and any harmful effects of Sn Whiskers resulting from use of lead-free "tin" shall be addressed and mitigated in accordance with GEIA-STD-0005-2, "Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems". At a minimum the following mitigations shall be employed when using lead-free Tin.

1. The Contractor shall use a Level 2B risk mitigation strategy.
2. Maintain minimum conductor spacing's > 0.018" (457 microns) (e.g. typically greater than 25 mil pitch).
3. Use conformal coating. The following coatings are listed in order of perceived effectiveness for tin whisker mitigation. Parylene, UR, AR, SR.
4. If unable to obtain leaded component with spacing of at least .0018" then:

   a. Pure tin finishes with < than 0.018" conductor spacing shall be Hot Solder Dipped per GEIA-STD-0006.
   b. Non tin or tin alloy finishes with <.0018" conductor spacing need to be cleared with the contracting agency

3.7.6.1.3 Notification. The Subcontractor shall track and notify Contractor where lead-free part termination materials and finishes, printed wiring board finishes, and assembly materials are used.

3.7.7 Identification. The BMS shall have part identification applied per the component product drawing. The component product drawing shall contain at minimum the product NSN(s).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. Unless otherwise specified in the contract, purchase order or herein, the supplier is responsible for performance of all inspections (examinations and tests) specified herein. Except as otherwise specified in the contract or purchase order, the supplier may use his own or any other suitable facilities for the inspections unless disapproved by the procuring activity. The supplier shall ensure that inspection facilities maintain quality and accuracy sufficient for the required inspections and that test and measurement equipment is calibrated in accordance with ISO 10012-1. The procuring activity reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure that supplies and services conform to prescribed requirements.

4.1.1 Responsibility for Compliance. All UUT shall meet all requirements of sections 3 and 5. The inspections set forth in this specification shall become a part of the supplier's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the supplier of responsibility for ensuring that all products or supplies submitted to the procuring activity for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to determine conformance to requirements, however this does not authorize submission of known defective material, either indicated or actual nor does it commit the procuring activity to accept defective material.

4.1.2 Materials and Manufacturing Processes. The supplier shall maintain, and make available for procuring activity review upon request, documentation verifying that materials and processes used in manufacture of UUT conform to specified requirements. As a minimum, documentation shall confirm the following:

a. Materials as specified in 3.2 through 3.2.2,
b. Design and construction as specified in 3.3,
c. Printed wiring as specified in 3.3.2.1,
d. Wire marking as specified in 3.3.2.2,
e. Soldering as specified in 3.3.2.3,
f. ESS as specified in 3.3.2.4,
g. ESD as specified in 3.3.2.5.

4.1.3 Automatic Test Equipment (ATE). When programmable ATE is used, the procuring activity shall review and approve the final test program(s) as well as the supplier's configuration control process for developing and controlling ATE software and hardware to ensure that the end item meets all requirements verified through ATE testing. The supplier shall notify the procuring activity of any changes to a previously approved ATE system or test program to determine whether a new review is required. Disapproval of a system or program shall render each affected ATE unusable for acceptance of UUT until the supplier has established and implemented a corrective action plan which includes either a correction or approved work-around acceptable to the procuring activity. An ATE configuration control process shall include the following, as applicable:

a. Design and coding standards,
b. Test program documentation,
c. Flow charts of program routines,
d. Test program source listings,
e. Configuration management of test programs,
f. Design and code reviews, quality assurance, and corrective action,
g. ATE hardware configuration identifiers, test configurations, and instrumentation procedures,
h. Appropriate documentation for any special logic incorporated into the UUT’s internal memory for manufacturing test purposes.

4.1.3.1 ATE Fault Insertion. Unless otherwise specified, ATE shall have fault insertion performed in accordance with Appendix A upon completion of ATE development. Appendix A is a general reference and will be customized based on the system. Fault insertion shall be approved by the procuring activity prior to ATE usage for acceptance of UUT.

4.1.3.2 Failure. Inability of the ATE to detect any inserted fault shall constitute a failure. Such failure shall be cause for refusal to allow additional examinations or tests until the cause of failure has been corrected and the corrective action approved by the procuring activity. In the event of a failure or the need to reestablish a confidence level for ATE fault detection reliability, the procuring activity reserves the right to require additional faults be inserted and tested.

4.2 Classification of Inspections. The inspection requirements specified herein (see table V) are classified as follows:

a. First article inspection (see 4.4).
b. Quality conformance inspection (see 4.5).

4.3 Inspection Conditions. Unless otherwise specified, all inspections shall be conducted under the following standard (room) ambient conditions:

a. Temperature: 77°F ± 18°F (30° ±10°C)
b. Relative humidity: uncontrolled room ambient
c. Atmospheric pressure: site pressure

4.4 First Article Inspection. When a first article inspection is required, three BMS shall be subjected to first article inspection. BMS subjected to first article preproduction inspection need not be manufactured using production tooling. BMS subjected to first article initial production inspection shall be manufactured using production tooling.

4.4.1 Inspection Routine. The first article samples shall be subjected to the inspections so indicated in Table III.

TABLE III. Inspection Requirements.

Inspection	Requirement Paragraph	Inspection Method	First Article (4.4) Samples 1	2	3	Quality Conformance (4.5) 100 % Inspection (4.5.1.1)	Lot-by-Lot Sampling (4.5.1.2)	Control Tests (4.5.2)
Weight	3.3.1	Scale	X					
Connector Receptacles	3.3.3.1	4.6.2.1	X					
Grounding	3.3.3.2	4.6.2.2	X					
Cables and Leads	3.3.5.1	Visual	X					
Workmanship	3.3.6	Visual	X	X	X		X2/	
Interfaces	3.4.1	4.6.1	X					
Sensor Connector	3.4.4.1	4.6.3.1.1	X	X	X			
Battery Master Input	3.4.4.2	4.6.3.1.2	X	X	X			
CAN Bus (ISO 11898) Interface	3.4.4.3	4.6.3.1.3	X	X	X			
Input Voltages	3.4.6.1	4.6.3.2.1	X	X	X		X1/	
Power Line to Case Isolation	3.4.6.2	4.6.3.2.2	X	X	X		X2/	
Input Power	3.4.6.3	4.6.3.2.3	X	X	X		X2/	
Transient Conditions	3.4.6.4	4.6.3.2.4	X	X	X			
Built-In Test	3.4.7	4.6.3.3.1	X	X	X	X		
Fault Detection	3.4.7	4.6.3.3.2	X	X	X			
Reprogrammability	3.4.8	4.6.3.4	X	X	X			
Pin Disconnects	3.4.9	4.6.3.5	X	X	X			
Functional Shock	3.5.1.1	4.6.4.1.1	X	X	X			
Severe Shock	3.5.1.2	4.6.4.1.2	X	X	X			
Gun Firing Shock	3.5.1.3	4.6.4.1.3	X	X	X			
Ballistic Shock	3.5.1.4	4.6.4.1.4						
Bench Handling Shock	3.5.1.5	4.6.4.1.5	X	X	X			
Vibration	3.5.2	4.6.4.2	X	X	X			X
High Temperature Storage	3.5.3.1	4.6.4.3.1	X	X	X			X
High Temperature Operation	3.5.3.2	4.6.4.3.2	X	X	X			X
Low Temperature Storage	3.5.4.1	4.6.4.4.1	X	X	X			X
Low Temperature Operation	3.5.4.2	4.6.4.4.2	X	X	X			X
Leakage (Immersion)	3.5.5	4.6.4.5			X			X
Humidity	3.5.6	4.6.4.6		X				
Steam and Waterjet Cleaning	3.5.7	4.6.4.7	X	X	X			
Salt Fog	3.5.8	4.6.4.8			X			
Chemicals	3.5.9	4.6.4.9	X					
Sand	3.5.10	4.6.4.10	X					
Dust	3.5.11	4.6.4.11	X					
Elevation - Operating	3.5.12	4.6.4.12	X					
Elevation - Nonoperating	3.5.13	4.6.4.13	X					
Altitude Change	3.5.14	4.6.4.14	X					
EMI/EMC	3.6	4.6.5			X			
Product Characteristics	3.7.1-3.7.6	4.7	X					
Identification	3.7.7	Visual					X 2/	
Packaging	5	Visual					X 2/	

1/ Major quality characteristic(s)   2/ Minor quality characteristic(s)

4.4.2 First Article Failure. Inability of a first article sample to pass any examination or test shall constitute a failure. Such failure shall be cause for refusal to grant first article approval. Such failure may, at the option of the procuring activity, be cause for refusal to allow additional examinations or tests until causes of faults have been corrected and the corrective action approved by the procuring activity.

4.4.3 Retention of First Article Approval. Unless extended by the procuring activity to other contracts, first article approval is valid only on the contract under which it is granted.

4.4.4 Disposition of Samples. Samples that have been subjected to first article inspection shall be indelibly marked "Test Sample" and shall not be delivered as new equipment under the contract.

4.4.5 Changes to Design, Processes, Procedures, or Location. Whenever a change is made in the design or in the manufacturing process, procedures, or facility location used in the production of BMS, the procuring activity shall be notified to determine whether or not BMS produced under the new conditions will require re-inspection of any of the requirements specified in 4.4.

4.5 Quality Conformance Inspection.

4.5.1 Inspection of Product for Delivery. Inspection of BMS for delivery shall consist of 100 percent and lot-by-lot sampling inspections.

4.5.1.1 100 Percent Inspection. 100 percent inspection shall consist of the inspections so indicated in Table III.

4.5.1.2 Lot-by-Lot Sampling Inspection. Lot-by-lot sampling inspection shall consist of the inspections so indicated in Table IV.

4.5.1.2.1 Lot-by-Lot Sampling Plan.

a. Basic method. Quality characteristics listed in Table III shall be inspected using the sampling plan shown in Table IV. Alternate sampling plans are not allowed except under an approved statistical process control (SPC) system conforming to the requirements outlined in paragraph 4.5.1.2.1 b.

TABLE IV. Lot-by-Lot Sampling Plan.

Lot size	Sample size	
	For major characteristics	For minor characteristics
2 to 13	Entire lot	3
14 to 25	13	3
26 to 50	13	5
51 to 90	13	6
91 to 150	13	7
151 to 280	20	10
281 to 500	29	11
501 to 1200	34	15
1201 to 3200	42	18
3201 to 10,000	50	22

NOTE: Accept lot on zero defects. Reject lot on one or more defects.

1. Tightened Inspection. Tightened inspection shall be introduced as soon as 2 out of 5 successive lots have been rejected and shall as a minimum, impose a 30% increase in sample size. Normal inspection sampling may be restored after 5 successive lots have been accepted under tightened inspection.
2. Reduced Inspection. Reduced inspection may be introduced when 10 successive lots have been accepted and shall as a maximum, permit a 30% decrease in sample size. Normal inspection sampling shall be restored if a lot is not accepted under reduced inspection.
3. Lot. A lot is defined as a collection of parts produced under essentially the same conditions and offered for inspection at one time.
4. Rejected Lot. A rejected lot may be 100 percent sorted (screened) to remove non-conforming parts and to determine acceptance of conforming parts.

b. Statistical Process Control (SPC) Sampling Method. Sampling plan requirements of 4.5.1.2.1a may be satisfied through the use of SPC as an alternate control method. An SPC plan detailing the methods for monitoring process control shall be approved by the procuring activity or agent. The plan, developed by the supplier, shall include as a minimum:

1. Types of control charts and their uses.
2. Process capability (Cpk) studies.
3. Criteria for determining out-of-control conditions.
4. Corrective actions to be taken if an out-of-control or out-of-tolerance condition is detected.
5. Training programs and qualification requirements of personnel executing the plan.
6. Provisions for reduced inspection.

The plan shall contain the results of process capability studies for the process being controlled. For variable data, the minimum Cpk for statistical control should be 1.33. For attribute data, a minimum process average of 99.73 percent is required.

4.5.2 Production Quality Control Tests. Production quality control testing is not required if ESS is performed. If ESS is not required (see 3.3.2.4 and 6.2), control tests shall be performed and shall consist of the inspections so indicated in Table III. Delivery of BMS that have passed 100 percent and lot-by-lot sampling inspections shall not be delayed pending control test results.

4.5.2.1 Control Test Sampling Plan. Unless otherwise specified (see 6.2), sample BMS shall be selected at the rate of 1 per each 100 produced.

4.5.2.2 Noncompliance. If a sample fails to pass control testing, the supplier shall notify the procuring activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all BMS that were manufactured with essentially the same materials and processes, and are considered subject to the same failure. Acceptance and shipment of BMS shall be discontinued until corrective action is acceptable to the procuring activity and retest of all failed requirements has shown that the corrective action was successful.

4.5.2.3 Disposition of Control Test Samples. BMS that have been subjected to control testing shall not be delivered as new equipment under the contract.

4.5.3 Non-conforming Parts. The supplier may rework or reprocess rejected BMS to correct non-conforming characteristics and resubmit them for inspection. Reworking/ reprocessing of BMS shall be within the confines of drawing and specification requirements, and shall require 100 percent inspection of corrected characteristics.

4.6 Methods of Inspection.

4.6.1 Engineering Analysis. The purpose of engineering analysis is to provide objective evidence as to the ability of the BMS to meet performance characteristics where component level testing or inspection is either not required due to previous experience and/or testing, or is not feasible due to unrealistic inspection conditions. Analysis may consist of evaluation of data accumulated from inspection, demonstration, test and product design requirements simulation, modeling, interpretation and/or parts similarity. Analysis may include engineering calculations if applicable. The resultant analysis of this data shall be organized to provide evidence that a particular requirement has been met.

4.6.2 Design and construction.

4.6.2.1 Electrical Connector Receptacles. Conformance to requirements specified in 3.3.3.1 shall be verified through visual inspection and through testing with a milliohmmeter with four-port Kelvin leads.

4.6.2.2 Grounding. Reserved

4.6.2.3 Dielectric Withstanding Voltage and Insulation Resistance. Not applicable.

4.6.2.4 Touch Surface Temperature. Reserved

4.6.3 Performance Tests. Unless otherwise specified in a particular case, the following applies to the tests specified herein:

4.6.3.1 Interfaces.

4.6.3.1.1 Sensor Connector. Reserved

4.6.3.1.2 Battery Master Input. Verify high and low voltages at 'ACTIVE' and 'STANDBY' Modes.

4.6.3.1.3 CAN BUS Interface. To determine conformance with 3.4.4.3, the UUT shall be tested in accordance with the SAE J1939 Standard.

4.6.3.2 Power Requirements.

4.6.3.2.1 Input Voltages. To determine conformance to 3.4.6.1, all performance tests shall be performed once with the supply voltage to the UUT set to the specified upper limit and once with supply voltages set at the lower limit.

4.6.3.2.2 Power Line to Case Isolation. To determine conformance to 3.4.6.2, verify that pins J1-A and J1-C are isolated from the UUT chassis by at least 1 MΩ DC resistance.

4.6.3.2.3 Input Power. To determine conformance to 3.4.6.3, with the input supply voltage set at the upper limit, verify that supply current never exceeds 0.4A 'ACTIVE' mode and 0.04A 'STANDBY' mode.

4.6.3.2.4 Transient Conditions. To determine conformance to 3.4.6.4, verify during each performance test that exported spikes and surges at UUT connector pins specified in 4.6.3.2.2 do not exceed specified limits. Testing is done in accordance to MIL-STD-1275D.

4.6.3.3 Built-in-Test.

4.6.3.3.1 BIT Verification. To determine conformance to 3.4.7, the UUT shall be powered up, and after 15 seconds commanded CAN Bus interface to transmit BIT status. It shall be verified that the UUT responds with message indicating no BIT errors.

4.6.3.3.2 Fault Detection. To determine conformance with 3.4.7, to the extent feasible, each specific fault type which BIT is designed to detect shall be inserted one at a time into the UUT. It shall then be verified after 15 seconds that the UUT responds to the BIT Status Request with fault indications.

4.6.3.4 Reprogrammability. To determine conformance with 3.4.8, the non-volatile memory in the UUT shall be loaded with data containing a known unique configuration identifier different from the identifier initially resident in the memory. Correct loading shall be demonstrated by verifying checksums and the configuration identifier stored in memory after reprogramming. It shall be verified that this reprogramming operation is complete within 15 minutes.

4.6.3.5 Pin Disconnects. To determine conformance to 3.4.9, verify continuity with cables connected and also verify discontinuity with cables disconnected.

4.6.4 Environmental Tests. Unless otherwise specified herein, environmental testing (test condition tolerances, failure criteria, etc.) shall be conducted in accordance with the general requirements of MIL-STD-810F. To verify that performance of UUTs have not been degraded beyond specification limits, the tests specified in Table V shall be performed at nominal 28 VDC input voltage. After testing, the UUT shall show no evidence of damage or deformation.

4.6.4.1 Shock.

4.6.4.1.1 Functional Shock. To determine conformance to 3.5.1.1, UUT shall be tested in accordance with MIL-STD-810F, Method 516.5, Shock, Procedure I, Functional, Ground Equipment, Modified, 15 g's, 75 ms, 18 half-sine shock pulses.

4.6.4.1.2 Severe Shock. To determine conformance to 3.5.1.2, UUT with typical mounting facilities shall be tested in accordance with MIL-STD-810F, Method 516.5, Shock, Procedure I, Functional, Ground Equipment, Figure 516.5-1, Modified, 30 g's, 18 ms, 18 half sine shock pulses without mounting provision failure or without degradation in function within 6 seconds after each shock. Prime power to the UUT shall not be interrupted by shock pulses.

4.6.4.1.3 Gun Firing Shock. The UUT shall be mounting in a configuration which simulates vehicle usage and meet requirements of 3.5.1.3 when tested using the test methods of MIL-STD-810F, Method 519.5, Gunfire Vibration, Procedure I. During exposure, verify that intermittent operation does not occur. After exposure the system shall meet the performance requirements of paragraph 3.4.

4.6.4.1.4 Ballistic Shock. The UUT shall be mounting in a configuration which simulates vehicle usage and meet requirements of 3.5.1.4 when tested using the test methods of MIL-STD-810F, Method 522, Ballistic Shock. During exposure, verify that intermittent operation does not occur. After exposure the system shall meet the performance requirements of paragraph 3.4.

4.6.4.1.5 Bench Handling Shock. The UUT shall be mounted in a configuration which simulates vehicle usage and meet requirements of 3.5.1.5 when tested using the test methods of MIL-STD-810F, Method 516.5, Shock, Procedure VI, Bench Handling. During exposure, verify that intermittent operation does not occur. After exposure the system shall meet the performance requirements of paragraph 3.4.

4.6.4.2 Vibration. To determine conformance to 3.5.2, UUT shall be tested in accordance with MIL-STD-810F, Method 514.5, Vibration, Procedure I, Category 8, Ground Mobile, and Appendix B of this specification. Prime power to the UUT shall not be interrupted during test.

4.6.4.3 High Temperature.

4.6.4.3.1 Storage. To determine conformance to 3.5.3.1, UUT shall be tested in accordance with MIL-STD-810F, Method 501.4, High Temperature, Procedure I.

4.6.4.3.2 Operation. To determine conformance to 3.5.3.2, UUT shall be tested in accordance with MIL-STD-810F, Method 501.4, High Temperature, Procedure II (modified). UUT sensors and control units will be segregated to their specific temperatures as listed in 3.5.3.2.

4.6.4.4 Low Temperature.

4.6.4.4.1 Storage. To determine conformance to 3.5.4.1, UUT shall be tested in accordance with MIL-STD-810F, Method 502.4, Low Temperature, Procedure I, Storage for 4 hours at induced temperature conditions for severe cold (C3) of Table 502.3-I, -60°F (-51°C).

4.6.4.4.2 Operation. To determine conformance to 3.5.4.2, UUT shall be tested in accordance with MIL-STD-810F, Method 502.4, Low Temperature, Procedure III, Operation with manipulation for 4 hours at the coldest Operational Cold (C2) temperature of Table 502.3-I.

4.6.4.5 Leakage (Immersion). To determine conformance to 3.5.5, the UUT shall be tested in accordance with MIL-STD-810F, Method 512.4, Leakage (Immersion), Procedure I, Basic Leakage. Immerse the non-operating UUT in water to a depth of 6 feet for 0.5 hours. Connector covers are permitted. Pressurized air may be used to remove water from connector pins after immersion.

4.6.4.6 Humidity. To determine conformance to 3.5.6, UUT shall be tested in accordance with MIL-STD-810F, Method 507.4, Humidity. Connector covers are permitted.

4.6.4.7 Steam and Waterjet Cleaning. To determine conformance to 3.5.7, UUT shall be subjected to steam cleaning with a cleaner conforming to P-C-437B Type II, P-D-220D, or commercial equivalent, followed by waterjet cleaning as follows. Jet pressure shall be applied perpendicular to the assembly from a distance of not more than one foot for steam and not more than three feet for waterjet cleaning. Jet pressure shall be 105±5 pounds per square inch gage (psig) for steam and 50±5 psig for waterjet. UUT shall be subjected to the jet at a rate not less than one square foot per minute. Connector covers are permitted.

4.6.4.8 Salt Fog. To determine conformance to 3.5.8, UUT shall be tested in accordance with MIL-STD-810F, Method 509.4, Salt Fog, Procedure I, Aggravated screening. Connector covers are permitted.

4.6.4.9 Chemicals. The UUT shall be exposed to vapors of and in direct contact with the chemicals specified in paragraph 3.5.9 for a period of 48 hours minimum as specified in MIL-STD-810F, Method 504, Contamination by Fluids. During exposure, verify that intermittent operation does not occur. After exposure the system shall meet the performance requirements of paragraph 3.4.

4.6.4.10 Sand. To determine conformance to 3.5.10, the UUT shall be tested in accordance with MIL-STD-810F, Method 510.4, Sand and Dust, Procedure II, Sand. During exposure, verify that intermittent operation does not occur. After exposure the system shall meet the performance requirements of paragraph 3.4.

4.6.4.11 Dust. To determine conformance to 3.5.11, the UUT shall be tested in accordance with MIL-STD-810F, Method 510.4, Sand and Dust, Procedure I, Dust. During exposure, verify that intermittent operation does not occur. After exposure the system shall meet the performance requirements of paragraph 3.4.

4.6.4.12 Elevation - Operating. To determine conformance to 3.5.13, the UUT shall be tested in accordance with MIL-STD-810F, Method 500.4, Low Pressure (Altitude), Procedure II, Operation/Air Carriage. Atmospheric pressure must withstand as high as 1060 millibars. During exposure, verify that intermittent operation does not occur. After exposure the system shall meet the performance requirements of paragraph 3.4.

4.6.4.13 Elevation - Nonoperating. To determine conformance to 3.5.14, the UUT shall be tested in accordance with MIL-STD-810F, Method 500.4, Low Pressure (Altitude), Procedure I, Storage/Air Transport. Atmospheric pressure must withstand as low as 945 millibars. After exposure the system shall meet the performance requirements of paragraph 3.4.

4.6.4.14 Altitude Change. To determine conformance to 3.5.15, the UUT shall be tested in accordance with MIL-STD-810F, Method 500.4, Procedure III, Rapid Decompression. UUT shall meet rates of ascent/descent of 10 meters/second in a non-operating environment.

4.6.5 Electromagnetic Compatibility. To determine conformance to 3.6, UUT shall be tested in accordance with applicable MIL-STD-461F methods. All conducted and radiated emissions tests on a UUT shall be complete before beginning any susceptibility testing on that UUT.

Table V. BMS Environmental Tests

ENVIRONMENTAL TEST	**TEST TO BE PERFORMED ON UUT DURING ENVIRONMENTAL TEST**
Functional Shock 4.6.4.1.1	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5

Severe Shock 4.6.4.1.2	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Gun Firing Shock 4.6.4.1.3	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Ballistic Shock 4.6.4.1.4	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Bench Handling Shock 4.6.4.1.5	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Vibration 4.6.4.2	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Temperature (operational) 4.6.4.3.2, 4.6.4.4.2	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Temperature (storage) 4.6.4.3.1, 4.6.4.4.1	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Leakage/Immersion 4.6.4.5	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Humidity 4.6.4.6	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Steam and Waterjet 4.6.4.7	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Salt Fog 4.6.4.8	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Chemicals 4.6.4.9	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Sand 4.6.4.10	

	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Dust 4.6.4.11	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Elevation - Operating 4.6.4.12	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Elevation - Nonoperating 4.6.4.13	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
Altitude Change 4.6.4.14	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5
EMI Compatibility 4.6.5	Perform pre-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5 Perform post-test 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5

4.7 Product Characteristics. Conformance to 3.7.1-3.7.6.1 shall be determined through system testing and engineering analysis (See 4.6.1) maintained and documented throughout the UUT life cycle.

4.8 Pre and Post-Environmental Tests. The UUT shall be validated by connecting the UUT to batteries (6TL, 6TAGM, or AGM Group 31) to determine operating conditions pre and post-test. The UUT shall be programmed with the correct type of battery it is to be validated for. Conformance of the UUT to Table V shall be determined by the passing of the following pre and post-tests:

4.8.1 Voltage. The UUT shall read and output a voltage within 5% of the actual battery voltage as compared to a secondary calibrated voltmeter.

4.8.2 Temperature. The UUT shall read and output a temperature within 5% of the actual battery temperature as taken from the UUT's temperature reading location. This shall be verified by a secondary calibrated source.

4.8.3 Current. The UUT shall be connected to a secondary load. The UUT shall read and output the current draw of the secondary load within 5% of the actual current draw as compared to a secondary calibrated ammeter.

4.8.4 State of Charge. The UUT shall read and output a state of charge within 5% of the actual battery state of charge as compared to a secondary calibrated battery analyzer. The UUT must be allowed to recalibrate (see section 4.8.4.1) with the battery system before the State of Charge test is run. Before recalibration, the UUT shall read and output a state of charge ±15% of the actual battery state of charge.

4.8.4.1 Recalibration. Recalibration is defined as one complete discharge and recharge cycle of a battery system. However, the contractor can submit a recalibration plan to the government for secondary approval.

4.8.5 State of Health. The UUT shall read and output the reserve capacities of a battery to report the state of health within 5% of the battery's state of health as reported in the battery manufacturer's specification sheet.

5. PACKAGING

Preservation, packing and marking of UUT shall be in accordance with the applicable packaging standard or packaging data sheet specified by the procuring activity.

6. NOTES

This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.

6.1 Intended Use. UUT manufactured in accordance with this specification are intended for use on military vehicles.

6.2 Acquisition Requirements. Acquisition documents must specify the following:

a. Title, number, revision, and date of this specification.
b. Title, number, revision, and date of part drawing.
c. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1).
d. First article inspection, if required.
e. Responsibility for inspection, if other than as specified herein (see 4.1).
f. If fault insertion is not required (see 4.1.3.1).
g. Quality control test sampling plan if other than specified in 4.5.2.1,
h. Level of packaging (see section 5).
i. Any deviation from this specification.

6.3 First Article. When first article inspection is required (see 3.1), the contracting officer should provide specific guidance to bidders as to whether they should include preproduction samples, initial production samples, or standard production samples from the supplier's current inventory. The acquisition document should include specific instructions regarding arrangements for examinations, approval of first article test results and disposition of first articles. Invitations for bids should provide that the procuring activity reserves the right to waive first article inspection, or any portion thereof, to those bidders offering a product which has been previously acquired or tested by the procuring activity or other responsible testing activity. Bidders offering such products should furnish evidence with the bid that prior first article approval is presently appropriate for the pending contract, or that first article inspection or any portion thereof, is inappropriate or unnecessary for the pending contract.

6.3.1 When Applied. First article inspection is applied when it is necessary to determine if a new supplier is qualified to produce UUT in full compliance with this specification and all applicable documents (see 3.1). First article inspection may also be applied when there is an interruption in production (normally one year or more), or when there is a change in the design or in the manufacturing methods or manufacturing facility location (see 4.4.5).

6.4 Definitions.

6.4.1 Environmental Stress Screening (ESS). Environmental stress screening of a product is a process which involves that application of one or more specific types of environmental stresses for the purpose of precipitating to hard failure, latent, intermittent, or incipient defects or flaws which would cause product failure in the use environment. The stress may be applied in combination or in sequence on an accelerated basis but within the product design capabilities.

6.4.2 Abbreviations and Acronyms.

A3	A program for upgrading performance of the Bradley Fighting Vehicle
ATE	Automatic Test Equipment
BIT	Built-In Test
BMS	Battery Monitoring System
CIDS	Critical Item Development Specification
Cpk	Process capability
DC	Direct Current
DoD	Department of Defense
DODISS	Department of Defense Index of Specifications and Standards
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
ESS	Environmental Stress Screening
g	Gravitational acceleration
Hz	Hertz
ICD	Interface Control Document
kHz	Kilohertz
kΩ	Kilohms
ma	Milliamp(s)
M2A3	A version of BFV
M3A3	A version of BFV
MHz	Megahertz
MIL-HDBK	Military handbook
MIL-STD	Military Standard
ms	Millisecond(s)
MΩ	Megohms
N/A	Not applicable
NED	Nuclear Event Detector
NSN	National Stock Number
PDT	Product Development Team
psig	Pounds per square inch, gage
RMS	Root mean square
SAE	Society of Automotive Engineers
SPC	Statistical Process Control

SSPC	Solid State Power Controller
TACOM	US Army Tank-Automotive Command
TBD	To be determined
TTL	Transistor-Transistor Logic
UDLP	United Defense Limited Partnership
UUT	Unit under test
VDC	Volts DC
V/m	Volts per meter
°C	Degree(s) Celsius
°F	Degree(s) Fahrenheit
Ω	Ohm(s)

APPENDIX A - FAULT INSERTION

10. SCOPE

This appendix contains the fault conditions to be verified during ATE development, and is a mandatory part of the specification.

20. APPLICABLE DOCUMENTS. Reserved.

30. REQUIREMENTS

30.1 Fault Conditions. Table A-1 contains a list of faults to be inserted into the ATE to verify that it is capable of detecting a faulty BMS. A list of acceptable readings is shown to provide a range of readings the ATE should print out. If the ATE is capable of printing the actual measured values, the printout of fault measurements shall be verified to be within the acceptable ATE reading range for each fault. Acceptable ATE readings allow for fault insertion equipment tolerances.

30.2 Fault Determination/Derivation. The faults and acceptable fault readings determined are based on the assumption that all measuring equipment will have a combined accuracy of 95 percent or better, including cable loss. The faults and acceptable readings listed below were derived by the following method:
Given the requirement that a voltage falls between "X VDC" and "Y VDC", then:

1. **Below Specification Requirement:**

a. Fault = (X - .12Y ± .05Y) VDC, but no less than 0.0.
b. Acceptable ATE reading = (X - .12Y ± .10Y) VDC, but no less than 0.0 for timing and no less than 0.05Y below 0.0 for other readings.

2. **Above Specification Requirement:**

a. Fault = (Y + .12Y ± .05Y) VDC.
b. Acceptable ATE reading = (Y + .12Y ± .10Y) VDC.

Table A-1. Fault Conditions.

Specification	Requirement Paragraph	Fault to Insert	Acceptable ATE
TBD	TBD	TBD	TBD

APPENDIX B - VIBRATION

10. SCOPE

This appendix contains the vibration conditions to be verified during development, and is a mandatory part of the specification.

20. APPLICABLE DOCUMENTS. Reserved.

30. REQUIREMENTS

30.1 Vibration: Components shall withstand vibration testing without degradation per MIL-STD-810F, Method 514.5, Procedure I, Category 20, in each orthogonal axis, per Figures 1, 2, and 3.

Broadband Random Vibration

Break Point #	Frequency (Hz)	PSD Amplitude (g2/Hz)
1	10	1.26E-04
2	62	4.93E-04
3	114	2.62E-03
4	166	1.73E-03
5	218	1.72E-03
6	271	7.10E-04
7	323	7.31E-04
8	375	7.75E-04
9	427	5.27E-04
10	479	1.53E-03
11	531	6.53E-04
12	583	1.14E-03
13	635	1.19E-03
14	687	3.85E-04
15	739	2.63E-03
16	792	1.58E-03
17	844	6.09E-04
18	896	2.50E-04
19	948	1.99E-04
20	1000	2.79E-04
21	2000	1.00E-01
	21	

Broadband G RMS =	4.69

Test Duration
150 Minutes for simulated 6000 miles

Sweeping Narrowband Random Vibration

Band # 1	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1	30.761641	2.59E-04
Sweep Rate	2	34.42374	3.33E-03
25 Min.	3	61.523281	1.38E-02
Linear	4	70.312325	3.65E-02
	5	82.763466	1.64E-02
Bandwidth	6	86.42556	2.56E-03
4	7	93.749763	4.12E-02
Hz	8	108.39816	6.52E-02

Band # 2	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1	61.523281	6.79E-04
Sweep Rate	2	79.101364	9.39E-03
25 Min.	3	106.93333	1.39E-02
Linear	4	140.62465	7.25E-03
	5	165.52693	2.71E-03
Bandwidth	6	172.85112	1.74E-02
8	7	187.49953	1.86E-02
Hz	8	216.79633	3.92E-03

Band # 3	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
12	7		
Hz	8		

Band # 4	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
16	7		
Hz	8		

Band # 5	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
20	7		
Hz	8		

Band # 6	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
24	7		
Hz	8		

Notes:
1. Control System Frequency Resolution = 1Hz
2. Narrowband sweep times are for one direction. (Example; 20 min. low to high, 40 min. low to high to low)

Table B-1: Vibration Qualification Specification in the Longitudinal axis for Sponson mounted Components

Broadband Random Vibration

Break Point #	Frequency (Hz)	PSD Amplitude (g2/Hz)
1	10	1.11E-04
2	62	2.60E-03
3	114	6.03E-03
4	166	3.44E-03
5	218	2.23E-03
6	271	6.01E-03
7	323	6.98E-03
8	375	3.46E-03
9	427	5.69E-03
10	479	8.54E-03
11	531	9.10E-03
12	583	9.07E-03
13	635	3.11E-03
14	687	1.23E-03
15	739	1.36E-02
16	792	2.10E-02
17	844	4.15E-03
18	896	9.74E-04
19	948	4.69E-04
20	1000	3.48E-04
21	2000	3.00E-02
	21	

Broadband G RMS =	3.64

Test Duration
150 Minutes for simulated 6000 miles

Sweeping Narrowband Random Vibration

Band # 1	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1	30.761641	6.87E-02
Sweep Rate	2	34.42374	6.59E-01
25 Min.	3	39.550682	1.47E-01
Linear	4	49.072144	2.04E-01
	5	54.931503	1.62E-01
Bandwidth	6	65.917801	2.40E-02
4	7	99.609123	5.90E-01
Hz	8	107.66574	2.20E-01

Band # 2	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1	61.523281	2.20E-03
Sweep Rate	2	98.144287	4.13E-02
25 Min.	3	121.58173	2.53E-02
Linear	4	140.62465	9.74E-02
	5	165.52693	2.62E-02
Bandwidth	6	183.10501	8.94E-02
8	7	199.21825	9.76E-03
Hz	8	215.33148	4.26E-03

Band # 3	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1	92.28492	4.31E-03
Sweep Rate	2	103.27122	1.55E-02
25 Min.	3	164.79451	1.34E-02
Linear	4	182.37259	1.47E-02
	5	197.7534	1.38E-03
Bandwidth	6	210.93698	5.17E-04
12	7	248.29041	6.65E-03
Hz	8	322.99722	3.82E-03

Band # 4	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
16	7		
Hz	8		

Band # 5	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
20	7		
Hz	8		

Band # 6	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
24	7		
Hz	8		

Notes:
1. Control System Frequency Resolution = 1Hz
2. Narrowband sweep times are for one direction. (Example; 20 min. low to high, 40 min. low to high to low)

Table B-2: Vibration Qualification Specification in the Transverse Axis for Sponson Mounted Components

Broadband Random Vibration

Break Point #	Frequency (Hz)	PSD Amplitude (g2/Hz)
1	10	5.43E-04
2	62	6.65E-03
3	114	8.00E-03
4	166	1.09E-02
5	218	6.37E-03
6	271	3.99E-03
7	323	6.01E-03
8	375	1.66E-03
9	427	1.60E-03
10	479	2.66E-03
11	531	1.36E-03
12	583	7.44E-04
13	635	5.21E-04
14	687	4.23E-04
15	739	1.49E-03
16	792	1.80E-03
17	844	9.09E-04
18	896	4.71E-04
19	948	3.50E-04
20	1000	4.11E-04
21	2000	3.00E-01
	21	

Broadband G RMS = 7.73

Sweeping Narrowband Random Vibration

Band # 1	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1	30.761641	7.05E-02
Sweep Rate	2	34.42374	7.01E-01
25 Min.	3	39.550682	1.34E-01
Linear	4	65.917801	2.88E-01
	5	70.312325	1.03E+00
Bandwidth	6	93.749763	2.15E-01
4	7	99.609123	2.95E-01
Hz	8	108.39816	3.11E-01

Band # 2	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1	61.523281	2.64E-03
Sweep Rate	2	68.847481	5.12E-03
25 Min.	3	79.101364	4.32E-02
Linear	4	121.58173	1.10E-02
	5	181.64017	1.46E-01
Bandwidth	6	187.49953	1.29E-01
8	7	199.21825	3.30E-02
Hz	8	216.79633	1.14E-02

Band # 3	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
12	7		
Hz	8		

Band # 4	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
16	7		
Hz	8		

Band # 5	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1	153.8082	5.24E-04
Sweep Rate	2	172.1187	2.18E-04
25 Min.	3	267.33331	2.19E-03
Linear	4	270.99542	4.70E-03
	5	388.18262	1.75E-04
Bandwidth	6	406.4931	9.49E-04
20	7	498.04562	1.25E-03
Hz	8	541.99084	1.35E-02

Band # 6	Break Point #	Center Frequency (Hz)	PSD Amplitude (g2/Hz)
	1		
Sweep Rate	2		
25 Min.	3		
Linear	4		
	5		
Bandwidth	6		
24	7		
Hz	8		

Test Duration
150 Minutes for
simulated 6000 miles

Notes:
1. Control System Frequency Resolution = 1Hz
2. Narrowband sweep times are for one direction. (Example; 20 min. low to high, 40 min. low to high to low)

Table B-3: Vibration Qualification Specification in the Vertical Axis for Sponson Mounted Components

APPENDIX C – RESTRICTED MATERIALS

10. SCOPE

This appendix contains the conditions on restricted materials to be verified during development, and is a mandatory part of the specification.

20. APPLICABLE DOCUMENTS. Reserved.

30. REQUIREMENTS

30.1 Design and Construction. Design and construction of the BMS including the factors listed below shall be in guidelines of the standards, specifications, pamphlets, regulations
The listed materials are contractually prohibited in final delivered products:

- **Asbestos**
- **Radioactive Materials**
- **Class I Ozone Depleting Substances**
- **Class II Ozone Depleting Substances**

***ODCs are most often used as propellants within automatic extinguishing system, and conformal coatings on electronics. A list of ODCs can be found at the following sites:

U.S. EPA: Class I Ozone-Depleting Substances
http://www.epa.gov/Ozone/ods.html

U.S. EPA: Class II Ozone-Depleting Substances
http://www.epa.gov/ozone/ods2.html

The following materials are defined as Restricted for use by BMS programs. The use of these materials in new design will require that they be identified and managed within the objectives of the Hazardous Materials Management Plan (HMMP).

- **Cadmium**
- **Hexavalent Chromium**
- **Lead** and compounds are permitted with the following restrictions:
  - Up to 4% lead by weight in copper alloys
  - Up to 0.35% lead by weight in steel alloys
  - Up to 0.4% lead by weight in aluminum alloys
  - Up to 4.0% lead by weight in aluminum alloys for engine parts only
- **Nickel** and compounds are permitted within the following restrictions:
  - Up to 0.1% nickel compounds by weight
  - All nickel-containing alloys

- Nickel in the form of a compound of lithium nickel dioxide in the lithium-ion batteries
- Nickel metallic plating including nickel strikes and barrier platings.
- Nickel oxide as ferrite in electronic components such as resistors or inductors.
- Nickel in brazing metal filler.

Although not contractually required, the objectives of Materials Engineering are to ensure the use of **Lead-free electrical components and Lead-free solder** be identified and monitored within the Hazardous Materials Management Plan (HMMP) at the component level for reset activities and new programs.

The following tables summarize some of the most prevalent callouts which can contain hazardous materials in the process.

Hexavalent Chromium

Applications	Specification Callouts Containing Hexavalent Chromium
Paints, Primers, Surface Finished on Aluminum, Steel, and other Metal Alloys Chromate Rinses on phosphate and oxide coatings Chromate Anodized Seals Supplementary finish on Zinc-plated fasteners.	ASTM B633 Type II, III MIL-C-5541 Class 1A and Class 3 MIL-DTL-5541, Type I Class 1A and Class 3 MIL-A-8625 Type I MIL-A-8625 Sealant DOD-P-15328 or MIL-C-8514 MIL-STD-171 7.3.1 and 7.3.3 Mil-S-8784

Cadmium

Common Applications	Specification Callouts Containing Cadmium
Fastener Plating, Plating on electrical connectors Present in ceramic and other material within electrical components	QQ-P-416 Types I & II

Nickel

Common Applications	Specification Callouts Containing Nickel
Stainless steel, Inconel, or other alloys. Electroplated and electroless plating for electrical components or other applications requiring corrosion and wear resistance, or electrical conductivity. Anodize Sealants	QQ-N-290 MIL-C-26074 MIL-A-8625 (Anodize sealant)

Clarification of terms:

Highly Toxic- material with an LD50*≤ 50 mg/kilogram of body weight. (*lethal dose which kills 50% of the test subjects) or if identified by a specific OSHA standard per 29CFR 1910, Sub-table Z.

Carcinogenic- material identified as a confirmed human carcinogen within the latest issue of the ACGIH TLV handbook

Alternative Material- A material that meets all technical and performance requirements of the prohibited materials, and does not incur major cost or schedule impacts.